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1983 TOXIC CHEMICAL SURVEY:
A SURVEY OF NINE IMPOUNDMENTS IN THE SAINT JOHN RIVER BASIN

IWD-AR-WQB-85-88

INLAND WATERS DIRECTORATE
ATLANTIC REGION
WATER QUALITY BRANCH
MONCTON, NEW BRUNSWICK

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in the

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Inland Waters Directorate

Environment Canada

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Atlantic Region

Moncton, N. B.

September 1985

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LETTER OF TRANSMITTAL

Water Quality Branch
Inland Waters Directorate
P. O. Box 861
Moncton, N. B.
19 September 1985

Dr. F.C. Duerden, Chairman
Regional Toxic Chemicals Committee
45 Alderney Drive
Dartmouth, N. S.
B2Y 2N6

Dear Dr. Duerden:

The Water Quality Branch is pleased to transmit to you a report entitled, "1983 Toxic Chemical Survey: A Survey of Nine Impoundments in the Saint John River Basin". This report reviews and discusses the pesticides and herbicide data, as well as other toxic chemical data gathered during a survey conducted in September/October 1983.

Observations and comments on this report would be welcome.

Yours sincerely,

D. H. Cullen, Chief
Water Quality Branch

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ACKNOWLEDGEMENT

The author wishes to thank Richard Arseneault for his assistance in collection of samples, and T.A. Clair and T.L. Pollock for their criticism of the report.

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ABSTRACT

Nine impoundments of the middle and upper Saint John River Basin were screened for selected pesticides, polychlorinated biphenyls, polynuclear aromatic hydrocarbons (PAH), mercury and cadmium in water, bottom sediment and fish tissue. Only persistent pesticides such as DDT (an organochlorine pesticide) were found in appreciable quantities in the three substrates. PAHs, mercury and cadmium were measured in most sediments however of these, only mercury was found in fish, occasionally at elevated levels.

RESUME

Des echantillons d'eau, de sediments de fond et de tissus de poissons ont ete recueillis de neuf reservoirs situes sur le basin de la Riviere Saint-Jean (haut et milieu). Ces echantillons ont ete analyses pour la presence de certains pesticides, de biphenyles polychlores, d'hydrocarbures polyaromatiques, de mercure et de cadmium. Seulement des pesticides persistants, tel que le DDT (un pesticide organochlore), ont ete mesures en quantite appreciable dans les trois substrats. Les hydrocarbures polyaromatiques, le mercure et le cadmium furent mesures dans la plupart des echantillons de sediments. Par contre, seulement le mercure a ete detecte dans le poisson, parfois a des niveaux eleves.

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1.0 INTRODUCTION

During the period 1979 to 1982, the toxic chemical surveys undertaken by the Water Quality Branch were confined to screening for chemicals high on Environment Canada's priority chemical list. Water and bottom sediment samples collected throughout the Atlantic Region were analyzed for PCB's, chlorobenzenes, pentachlorophenol, mercury, etc. These surveys resulted in three reports (1, 5, 6).

In 1983, public and government concern regarding agricultural chemicals as contaminants with a significant potential for adverse effects on the aquatic environment, prompted the Department of Environment to initiate programs designed to identify and quantify toxic agricultural chemicals in the aquatic environment and to investigate their pathways, persistence and ultimate fate (22).

Agricultural chemicals are used throughout the Atlantic Region but areas of concern are those where agricultural activity is concentrated as in the Saint John River Basin, Cornwallis-Annapolis River Basin and most of Prince Edward Island. Approximately 80% of the agricultural chemicals used in New Brunswick are applied in the Saint John River Basin (22).

Since waterways serve as a major transport mechanism for toxic agricultural chemicals and since many of these substances and degradation products are associated with suspended sediment, sediment sinks such as reservoirs, dams, lakes and deltas are logical areas to investigate. The middle and upper Saint John River with numerous

impoundments is an ideal area to identify and quantify toxic agricultural chemicals in water, bottom sediment and resident biota (22).

This report reviews and discusses the pesticide and herbicide data, as well as other toxic chemical data gathered during a survey of nine impoundments in the Saint John River Basin in September/October 1983.

2. METHODOLOGY

2.1 Sampling Program

Water, bottom sediment and fish muscle samples were collected at eight man-made impoundments in the Saint John River Basin. Three of the sites were located on the main stem of the Saint John River with the other five sites on tributaries in the Upper Basin. The description of the sample sites and corresponding NAQUADAT station designations are listed in Table 1 and are shown on Figure 1.

2.2 Parameters

The parameters analyzed during the study reflect the historical and present day use patterns in the agriculture oriented basin as well as the laboratory capability to analyze pesticides and herbicides. The parameters include organochlorine, organophosphate and carbamate pesticides, and chlorophenoxy and triazine herbicides. Major ions and metals were also analyzed. Although Mancozeb (a dithio carbamate fungicide) and dinoseb (a dinitrophenol herbicide) ranked one and two for total usage in 1982 they were not within the laboratory capability at the time of the survey. A listing of all parameters analyzed in water, bottom sediment and fish with corresponding NAQUADAT parameter codes and detection limits may be found in Table 3.

2.3 Field Methodology

Water samples for all pesticides and herbicides were collected in

TABLE 1 : SAMPLING SITES

SITE	NAQUADAT #	SITE DESCRIPTION
1	01NB01AD0006 51NB01AD0006 90NB01AD0006	MADAWASKA RIVER HEADPOND 1.2 KM BELOW TCH
2	01NB01AF0007 51NB01AF0007 90NB01AF0007	GREEN RIVER RESERVOIR 100 M NORTH OF FRASER NURSERY PUMPING STATION
3	01NB01AF0005 51NB01AF0005 90NB01AF0005	SAINT JOHN RIVER AT GRAND FALLS HEADPOND, 150 M ABOVE DAM
4	01NB01AG0002 51NB01AG0002 90NB01AG0002	AROOSTOOK RIVER HEADPOND AT CANADA - UNITED STATES BORDER
5	01NB01AH0009 51NB01AH0009 90NB01AH0009	TOBIQUE RIVER HEADPOND 1.8 KM W OF CONFLUENCE OF BIG FLAT BROOK
6	01NB01AH0010 51NB01AH0010 90NB01AH0010	SISSON BRANCH RESERVOIR IN CENTER OF BASIN 400 M ABOVE DAM
7	01NB01AJ0003 51NB01AJ0003 90NB01AJ0003	SAINT JOHN RIVER AT BEECHWOOD HEADPOND , 600 M ABOVE DAM
8	01NB01AK0009 51NB01AK0009 90NB01AK0009	SAINT JOHN RIVER AT NEW NACKAWIC BRIDGE , POKIOK
9	01NB01AK0019 51NB01AK0019	SAINT JOHN RIVER AT MACTAQUAC HEADPOND , 100 M FROM HEADLANDS OF WALINAIK COVE

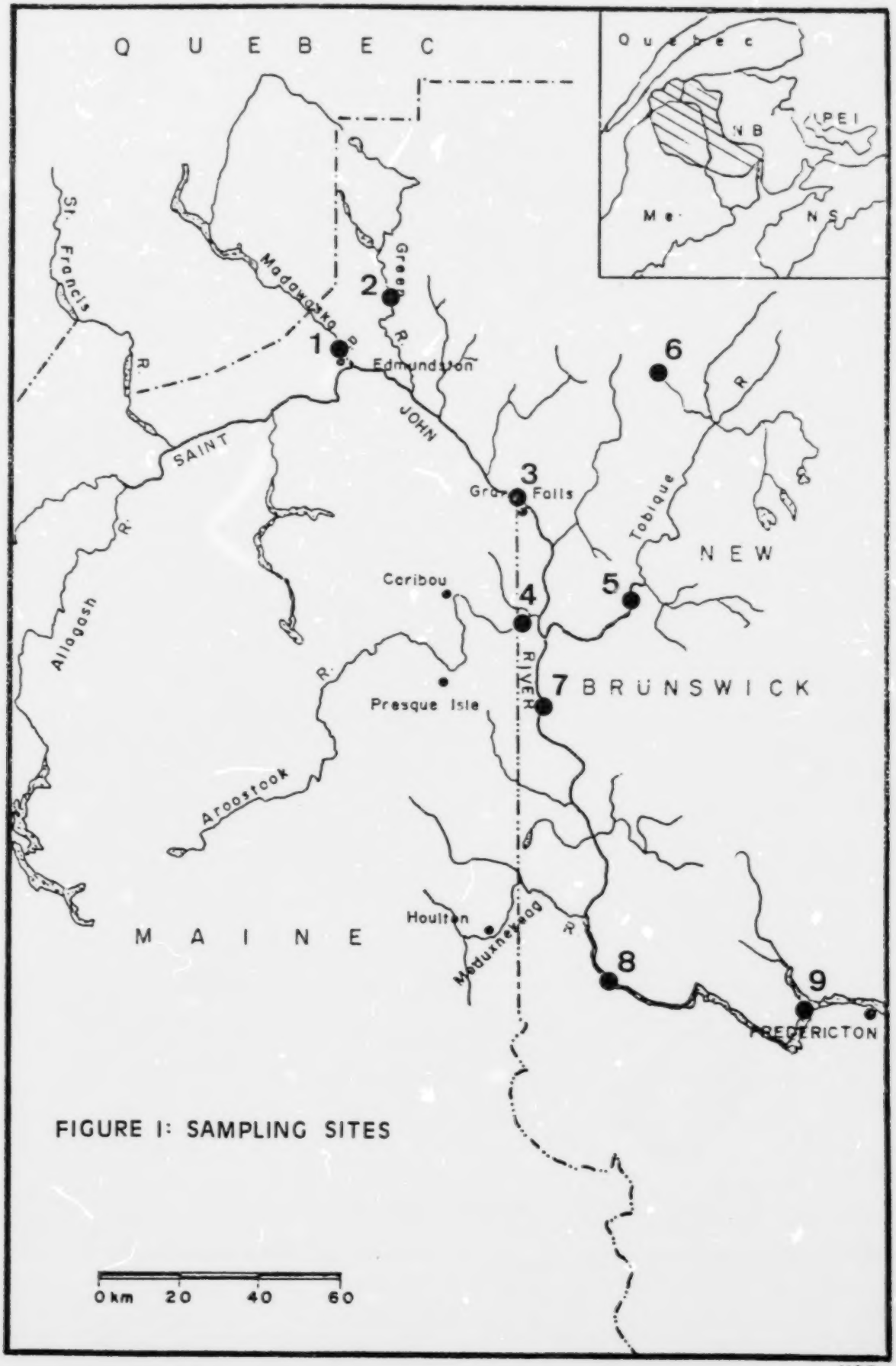

FIGURE I: SAMPLING SITES

three 4-L amber glass bottles. Surface samples were collected using a weighted iron sampler lowered 0.3 m below the surface. Depth samples were collected approximately one meter from the bottom with a 2.0 L Kemmerrer Plus sampling bottle (specially designed for insecticide, halogenated hydrocarbon, and trace metal sampling). Major ions and metals were collected directly with polyethylene bottles using the same sampling methods.

The methods of sample preservation are summarized in Table 2. Pesticide and herbicide samples were stored at 4°C prior to analysis.

Bottom sediment was collected using a 15 x 15 cm Ekman dredge. Once collected the sample was carefully released into a clean pyrex tray. The top 2 cm was sub-sampled with an aluminum scoop and placed in an aluminum container which had been prewashed with acetone and hexane. Three individual bottom samples were collected at each site. The samples were frozen immediately.

Fish samples were collected using a 23 m x 1.2 m gill net with a 3.8 cm mesh. The net was strung parallel to shore in approx. 2.5 m of water in the late afternoon and tended early the following morning. The fish were retrieved, grouped by species and size and filleted (muscle tissue) in sample size appropriate for the required analysis. The samples were frozen immediately.

All water, sediment and fish samples were returned to the Water Quality Branch laboratory within four days of their collection.

TABLE 2 : METHODS OF PRESERVATION

PARAMETER	PRESERVATION
METALS	1 ML CONCENTRATED NITRIC ACID (ULTREX)/500 ML
ORGANOCHLORINES PEST. ORGANOPHOSPHATE PEST. POLYCHLORINATED BIPHENYLS	100 ML HEXANE/ 4-LITERS,STORE AT 4 DEG.C.
CARBAMATE PEST. CHLOROPHENOXY HERB.	ADJUST SAMPLE TO PH 3 WITH 50% SULPHURIC ACID , ADD 40 GRAMS SODIUM SULPHATE, STORE AT 4 DEG.C.
TRIAZINE	ADJUST SAMPLE TO PH 8 WITH 0.1 SODIUM HYROXIDE , ADD 200 ML OF METHYLENE CHLORIDE, STORE AT 4 DEG.C.

2.4 Quality Assurance

Water and sediment samples were spiked with prescribed quantities of prepared spiking solution and preserved or frozen with the regular samples.

2.5 Laboratory Methodology

Analyses were performed using standard analytical procedures described in the Water Quality Branch Methods Manual (4) as well as methods adopted from other sources. A brief description of the

methodology employed is available in the NAQUADAT Dictionary of Parameter Codes (5). The codes and detection limits for the parameters (with exception of major ions) analyzed in 1983 are presented in Table 3.

Parameter codes with 89--- series numbers represent in-house codes and are awaiting NAQUADAT numbers. The methods for these parameters are summarized as follows:

(a) Carbamate Pesticides in Bottom Sediment
(Carbofuran, Aldicarb, Carbaryl)

Twenty gram portions of the sample were extracted with 3 x 100 mL volumes of ethyl acetate using an ultrasonic homogenizer. The extracts were cleaned up via coagulation/filtration and liquid partitioning. They were then dried over sodium sulphate and reduced to a final volume of 2 mL with hexane. Analysis was carried out by gas liquid chromatography using a nitrogen/phosphorus selective detector. The detection limit for the method is 0.01 mg/kg.

(b) Organophosphate Pesticides in Bottom Sediment
(Guthion, Phorate, Malathion, Imidan, Dimethoate, Fenitrothion)

A twenty gram portion of the sample was extracted with a 1:1 acetone-hexane mixture in an ultrasonic homogenizer. The extract was filtered, washed with water, extra hexane added, and dried over anhydrous sodium sulphate. The extract was reduced in volume and put on a Florisil column. The species of interest were then eluted off the

column with petroleum ether and mixtures of diethyl ether in petroleum ether. The solvent of each fraction was changed to iso-octane by evaporating off the ethers on a rotary evaporator; the fractions were then diluted to volume. Analysis for the organophosphates was carried out on a gas chromatograph using a thermionic specific detector (TSD).

(c) Triazine Herbicides in Bottom Sediment
(Atrazine, Metribuzine, Simazine)

A twenty gram portion of the sediment was extracted with methanol in an ultrasonic homogenizer. The methanol extract was filtered, diluted with water and back extracted with methylene chloride. The methylene chloride solution was dried over anhydrous sodium sulphate, then evaporated to dryness under reduced pressure. The residue was taken up in ethyl acetate, diluted to volume, and analyzed on a gas chromatograph using a TSD.

(d) Lipid Content in Fish

Ten grams of sample are extracted with 2 x 100 mL portions of acetonitrile using an ultrasonic homogenizer. The extract is filtered through a 3-layer glass microfibre filter into a tared round-bottom flask. The solvent is removed on a rotary evaporator at reduced pressure and the weight of the residue determined as lipid.

TABLE 3 : PARAMETER CODES AND DETECTION LIMITS

PARAMETER	WATER(UG/L)		SEDIMENT(MG/KG)		FISH(MG/KG)	
	PARAMETER CODE	DETECTION LIMIT	PARAMETER CODE	DETECTION LIMIT	PARAMETER CODE	DETECTION LIMIT
P,P-DDT	18000L	0.001	18009L	0.001	18602L	0.001
O,P-DDT	18005L	0.001	18008L	0.001	18606L	0.001
P,P-DDD	18010L	0.001	18012L	0.001	18611L	0.001
P,P-DDE	18020L	0.001	18026L	0.001	18621L	0.001
P,P-METHOXYCHLOR	18030L	0.01	18034L	0.05	18631L	0.05
HEPTACHLOR	18040L	0.001	18043L	0.001	18641L	0.001
HEPTACHLOR EPOXIDE	18045L	0.001	18048L	0.001	18646L	0.001
ALPHA-ENDOSULFAN	18050L	0.01	18054L	0.01	18651L	0.01
BETA-ENDOSULFAN	18055L	0.01	18058L	0.01	18656L	0.01
ALPHA-(CIS)CHLORDANE	18060L	0.005	18063L	0.005	18661L	0.005
GAMMA-(TRANS)CHLORDANE	18065L	0.005	18068L	0.005	18661L	0.005
LINDANE(GAMMA-BHC)	18070L	0.001	18079L	0.001	18671L	0.001
ALPHA-BHC	18075L	0.001	18074L	0.001	18676L	0.001
MIREX	18125L	0.001	18128L	0.001	-	-
ALDRIN	18130L	0.001	18133L	0.001	18632L	0.001
ENDRIN	18140L	0.01	18143L	0.01	18642L	0.01
DIELDRIN	18150L	0.001	-	-	-	-
AROCHLOR TOTAL	18164L	0.005	18177L	0.005	18669L	0.005
PHORATE	18300L	0.005	89048L	0.005	89049L	0.005
GUTHION	18190L	0.05	89045L	0.01	89044L	0.01
MALATHION	18250L	0.01	89052L	0.005	89053L	0.005
DIMETHOATE	18340L	0.01	89054L	0.005	-	-
IMIDAN(PHOSMET)	18205L	0.02	89058L	0.005	-	-
FENITROTHION	-	-	89040L	0.005	-	-
FENITROOXON	-	-	89060L	0.01	-	-
S-METHYL FENITROTHION	-	-	89070L	0.01	-	-
CARBOFURAN	89271L	0.025	89272L	0.01	-	-
ALDICARB	18444L	0.02	89056L	0.05	-	-
CARBARYL	18400L	0.025	88401L	0.05	-	-
ATRAZINE	89802L	0.05	89803L	0.005	89840L	0.02
METRIBUZINE	89820L	0.14	89821L	0.014	89842L	0.04
SIMAZINE	89818L	0.05	89819L	0.005	-	-
2,4-D	18500L	0.01	18501L	0.004	89482L	0.004
2,4,5-T	18510L	0.01	18511L	0.002	89484L	0.002
BENZO (A) PYRENE	-	-	18910L	0.0007	89721L	0.001
BENZO (B) FLUORANTHENE	-	-	18911L	0.0007	89722L	0.001
BENZO (G,H,I) PERYLENE	-	-	18912L	0.001	89723L	0.001
BENZO (K) FLUORANTHENE	-	-	18913L	0.003	89724L	0.001
FLUORANTHENE	-	-	18914L	0.001	89725L	0.001
INDENO (1,2,3-CD) PYRENE	-	-	18915L	0.001	89726L	0.001
CADMIUM	48302P	1.0	48054L	0.1	48601L	0.025
MERCURY	80315P	0.02	80052L	0.02	80602L	0.1
LIPID	-	-	-	-	89990L	0.5

3. RESULTS AND DISCUSSION

3.1 Data Screening

The number of samples analyzed during the survey for each parameter or parameter grouping and the number of positive values determined, are summarized in Table 4. The individual parameters comprising each group are given in Table 3.

As shown in Table 4, organophosphate (OPs) pesticides and triazine herbicides were not detected in water, sediment or fish tissue samples. Chlorophenoxy herbicides were not detected in sediment or fish tissue however a single value of 0.02 ug/L for 2,4,5-T was found in a bottom water sample at Grand Falls Headpond. The surface water sample was below the detection limit of 0.01 ug/L.

In a 1982 survey during June (1) triplicate bottom sediment samples were analyzed for guthion (an organophosphate), atrazine (a triazine herbicide) and 2,4-D and 2,4,5-T (chlorophenoxy herbicides) at six of the nine sites sampled in 1983. In that survey, the six common sites yielded only a single low level value for guthion at Beechwood. Moreover, these parameters were not detected at all at twelve additional sites in Nova Scotia and P.E.I. at that time.

Organophosphate pesticides account for approximately sixty-five percent of the agricultural pesticides used in the Saint John River Basin (2) however they degrade rapidly in the environment and often go undetected (3). Chlorophenoxy herbicides have half lives of one to

TABLE 4: SUMMARY OF NUMBER OF SAMPLES VERSUS POSITIVE VALUES RECORDED

PARAMETER	WATER		SEDIMENT		FISH	
	TOTAL SAMPLES	POSITIVE VALUES	TOTAL SAMPLES	POSITIVE VALUES	TOTAL SAMPLES	POSITIVE VALUES
CARBAMATE PESTICIDES	14	5	27	0	-	-
ORGANOCHLORINE PESTICIDES	14	14	27	27	47	46
ORGANOPHOSPHATE PESTICIDES	13	0	27	0	47	0
CHLOROPHENOXY HERBICIDES	14	1	27	0	44	0
TRIAZINE HERBICIDES	14	0	27	0	37	0
POLYCHLORINATED BIPHENYLS	14	1	27	4	47	10
POLYNUCLEAR AROMATIC HYDROCARBONS	-	-	15	15	26	0
CADMIUM	-	-	18	18	47	0
MERCURY	-	-	18	18	32	28

several weeks, while triazine herbicides are considered environmentally persistent and accumulation may occur (4).

The timing of the 1983 survey (Sept. 20 - Nov. 2) was probably the principal factor for the lack of detectable values. The heavy herbicide applications made during spring planting in May and organophosphate application during the growing season would have had 3 to 5 months to degrade prior to sampling. This however, was not the case in 1982 when the survey was conducted in June suggesting other factors such as the quantity of active ingredient and dilution were primary factors influencing the number of detectable values.

3.2 Carbamate Pesticides

Carbamate pesticides as a group account for approximately 35 percent of the agricultural pesticides used in the Saint John River Basin (2). Three pesticides in this group, carbofuran, aldicarb and carbaryl (Sevin), were analyzed in water and sediment samples in 1983.

Carbofuran was detected in five of fourteen water samples with values ranging from 0.03-0.06 ug/L, slightly above the detection limit of 0.025 ug/L. These values were determined at headpond sites on the main stem of the Saint John River at Beechwood (surface), Pokiok (surface and bottom) and Mactaquac (surface and bottom). Carbofuran was not detected in any of the twenty-seven sediment samples collected during the survey. Aldicarb and carbaryl were not detected in water or sediment samples.

This accords with a 1981 survey where carbofuran was not detected in water or sediment at twenty-one sites, however all those sites were located in areas of limited agricultural activity (5). Similarily in 1982, carbofuran was not detected in triplicate samples collected at twenty-six sites. Eighteen of these sites however were located in areas of moderate to heavy agriculture (1).

Carbofuran is highly susceptible to base-catalyzed hydrolysis, resulting in moderate to rapid degradation. The hydrolysis half life of carbofuran is 35, 6 and 0.25 days at a pH of 7, 8 and 9, respectively. It becomes increasingly more stable as pH decreases with an hydrolysis half life of 600 days at pH 5.5 (25). In Appendix VI, the pH values of the surface water at the nine sample sites ranged for 6.1 to 6.6. According to the hydrolysis curve, the half life would range from 100-150 days (25). Evidence suggests microbial and photolytic processes could also contribute to losses of the insecticide from the aquatic environment (25).

The carbofuran values detected at Pokiok and Mactaquac also coincided with the lowest pH values of 6.2 and 6.1 respectively.

Available information suggests that only a small fraction of carbofuran will be associated with the sediment and not likely to exceed the concentrations in the water to any appreciable extent. Therefore, sorption is not a significant pathway of carbofuran from the water phase. Similarly, the water octanol partition coefficient would indicate little accumulation in fish.

Several studies have verified the extreme toxicity of carbofuran to several aquatic organisms in the range of 0.02 to 1 mg/L (25). The maximum acceptable limit for carbofuran in domestic water is 100 ug/L. Limits are not specified for the protection of aquatic life.

3.3 Organochlorine Pesticides

Sixteen organochlorine (OC) pesticides (Table 3) were measured in water, sediment and fish tissue at nine sites. The organochlorine data may be found in Appendices 1, 2, 3. A data summary of total OCs in water, sediment and fish is presented in Table 5.

In water, the ubiquitous nature of alpha ( ) BHC resulted in detection limit values (0.001 - 0.006 ug/L) being found at all sampling sites. Lindane or gamma BHC although below the noted detection limit, was quantitified at 0.0003 ug/L at six of nine sample sites. In contrast, no BHC or other OCs were detected at 34 sites in New Brunswick, Nova Scotia and Prince Edward Island during a 1979 survey (5), however on the prairies of Western Canada a mean value of 0.005 ug/L for alpha BHC was found in 96% of 279 tests (3).

The values for BHC in surface waters appear much lower than those measured in samples from two precipitation sample sites at Kejimkujik National Park, N.S. and Ellerslie, P.E.I. operated by Atlantic Region Water Quality Branch. Seventy-five bulk samples (1 to 7 Liters) collected from 1980-1983 had a range (mean) of 0.002 to 0.070 (.020) ug/L and TR to 0.023 (.0050) ug/L for BHC and Lindane respectively (7,8,9). Similar values were also found in precipitation in Alberta

(3).

Lindane or -BHC were not included in the list of pesticides sold in N.B. in 1982 (2), therefore one may conclude, as did Gummer (3) and Brun (9) that the principle pathway for -BHC and Lindane was long range atmospheric transport. Alpha BHC and Lindane were not found in either sediments or fish tissue samples.

For the protection of freshwater aquatic life, lindane should not exceed 0.01 mg/L (10). It is not specified for BHC.

Organochlorines were detected in bottom sediments at all sites with a value range of 0.007 to 0.130 mg/kg (Table 5) and were comprised solely of DDT and its metabolites. The highest value, 0.130 mg/kg was the average determined in triplicate sediments from the Aroostook River Headpond near the Maine-New Brunswick border. Similar results were realized during the Water Quality Branch surveys in 1979 and 1980 when DDT and its metabolites were detected in fourteen of twenty-nine sites in the Atlantic Region (5). The values ranged from 0.001 to 0.110 mg/kg with the upper limit value detected at the same site on the Aroostook River as in 1983. The higher levels in the Aroostook River are probably the result of intensive agriculture and high past usage of DDT in the basin. During the same survey DDT was not detected in Grand Falls Headpond samples. In 1976, sediment samples were collected at twenty sites on the main stem and tributaries of the Saint John River. DDT was detected at eighteen of the sample sites with a range of 0.006 - 0.095 mg/kg (unpublished data). Although the sampling sites differed from survey to survey, the overall values in the region and specifically the

Saint John River Basin have remained stable for the seven years separating the three surveys.

Sediment core studies in Lake Ontario in 1976 by Frank et al. revealed the highest DDT levels were found in the top 1 cm of sediment and decreased with the depth of sediment samples (11). Interpolating their values, a 2-3 cm thick sediment sample may range from 0.050 to 0.129 mg/kg as DDT. Other Lake Ontario studies in the 1970's had DDT levels ranging from 0.018 to 0.066 mg/kg. The high metabolic activity in the Great Lakes appears to be resulting in declines in DDT and metabolites (11). The stability of values in fluvial sediment collected at most sites in the Atlantic Region is probably the result of a lower metabolic activity and more transient nature of the sediments.

Environmental problems associated with organochlorines result from three features of these compounds: (1) persistence; (2) widespread use; and (3) ability to bioaccumulate in aquatic organisms, all of which are well documented.

DDT and its metabolites were found in 46 of 47 fish tissue samples, representing all sites except the Saint John River at Mactaquac (no fish collected), with values ranging from ND to 0.34 mg/kg. Trace levels of beta-Endosulfan, alpha-Chlordane, gamma-Chlordane and alpha-BHC were also found in many samples. The range and median values for all species by site is provided in Table 5.

The highest levels of DDT and its metabolites were found in

longnose (Catostomus commersoni) and white sucker (Catostomus catostomus) samples collected in the Aroostook River with levels of 0.27 - 0.34 mg/kg in the 25-28 cm size class. This suggest the invertebrate population, which accounts for the bulk of the suckers food intake, has bioaccumulated the available DDT in the sediments. A similar size class of suckers in the Green River Reservoir had very low levels of DDT and its metabolites (0.003 - 0.007 mg/kg). The levels of DDT in sediment were also very low. A smaller size grouping of suckers at the Aroostook River had approximately one half as much total DDT (0.118 - 0.155 mg/kg) as the larger group. Yellow perch (Perca flavescens) samples from 6 sites ranged from 0.007 - 0.13 mg/kg.

Fish tissue samples analyzed in 1972 as part of the Saint John River Basin Study resulted in much higher levels of DDT and metabolites than in the same species during the 1983 survey (12). A comparison of total DDT values for fish samples in 1972 and 1983 is presented in Table 6. During the 1972 survey, perch and suckers were collected from Glasier Lake, Saint John River at Mactaquac, Oromocto Lake and Grand Lake. Yellow perch from these sites ranged from 0.120 to 1.53 mg/kg total DDT whereas white suckers ranged from 0.165 to 0.644 mg/kg. These levels were 4 to 20 times higher than those from the 1983 survey. The size of fish, unknown for the 1972 survey, may be a contributing factor considering the potential for bioaccumulation of organochlorines usually increases with age. The availability of DDT in sediment in 1972 was almost twice the total DDT available in 1983, also increasing the potential for bioaccumulation (12).

TABLE 5: SUMMARY OF TOTAL ORGANOCHLORINES IN WATER, SEDIMENT, AND FISH(ALL SPECIES)

SITE		WATER (UG/L)	SEDIMENT (MG/KG)	#	FISH(MG/KG) RANGE	MEDIAN
1 GREEN R. RESERVOIR	SURFACE	0.001	0.007	17	.003-.162	0.008
	BOTTOM	0.001				
2 MADAWASKA RIVER	SURFACE	0.006	0.007	7	.001-.007	0.002
3 SJR AT GRAND FALLS	SURFACE	0.001	0.007	4	.025-.072	0.036
4 TOBIQUE RIVER	SURFACE	0.001	0.028	6	.019-.060	0.050
	BOTTOM	0.002				
5 SISSON BR. RESERVOIR	SURFACE	-	0.036	2	L.001-.194	-
	BOTTOM	0.004				
6 ARDOSTOOK RIVER	SURFACE	0.001	0.130	6	.118-.34	0.270
	BOTTOM	0.001				
7 SJR AT BEECHWOOD	SURFACE	0.002	0.042	1	0.074	-
8 SJR AT POKIOK	SURFACE	0.001	0.036	4	.041-.13	0.069
	BOTTOM	0.002				
9 SJR AT MACTAQUAC	SURFACE	0.002	0.057	0	-	-
	BOTTOM	0.002				

TABLE 6 : COMPARISON OF TOTAL DDT LEVELS IN FISH(MG/KG) - 1972 AND 1983

SITE	SPECIES	TOTAL DDT 1972	TOTAL DDT 1983
SJR AT GRAND FALLS	WHITE SUCKER	0.360	0.054 (2 SAMPLES)
TOBIQUE RIVER	YELLOW PERCH	0.170	0.033 (3 SAMPLES)
	WHITE SUCKER	0.166	0.048 (3 SAMPLES/ LONGNOSE)
SJR AT BEECHWOOD	YELLOW PERCH	0.261	0.074
	YELLOW PERCH	1.040	

A study of five rivers in the Hudson Bay Lowland, Ontario (13) reported organochlorine residues in white sucker (whole fish) of 0.001 - 0.011 mg/kg for a 33 - 46 cm size range. Organochlorines were not detected in bottom sediments at the same sites.

Other species having relatively elevated levels of DDT and metabolites during the 1983 survey included a land-locked salmon (Salmo salar) from the Sisson Branch Reservoir and a lake whitefish (Coregonus clupeaformis) from Green River Reservoir which had mean values of 0.194 and 0.162 mg/kg respectively.

The organochlorine compounds, which are considered lipophilic, were generally proportional to the lipid content in the samples. The lipid content listed in Appendix III, also varied with the species. The lake whitefish has a high lipid content whereas the perch is very low. The larger size class of suckers discussed earlier in respect to highest DDT levels also had the highest lipid content, however the same size class at Green River Reservoir has about one half the lipid content. No correlations were carried due to variation from one species to another and the small number of values within each species.

3.4 Polychlorinated Biphenyls

Polychlorinated biphenyls (PCBs) were measured in water, sediment and fish tissue samples. The data are presented in Appendices 1, 2 and 3 and are summarized in Table 7.

A single positive value of 0.098 ug/L was detected in the surface

water sample at the Saint John River at Beechwood headpond and a trace value was recorded at the Madawaska River.

PCBs, an industrial organochlorine exhibit similar chemical characteristics similar to the organochlorine pesticides discussed in the previous section. PCBs are relatively insoluble in water and rapidly adsorb to the sediment. It has been suggested that detectable levels in water would be expected only near the source of pollution (12).

In the environment, PCBs persist and accumulate in biological tissue in much the same manner as the organochlorine pesticides, although they have a considerably lower direct toxicity (12).

In sediments, PCBs were found at three headpond sites on the main stem of the Saint John River at Beechwood, Pokiok and Mactaquac. They were detected in one of the triplicate samples at Pokiok and Mactaquac and two of three samples at Beechwood. The four positive results ranged from 0.008 to 0.016 mg/kg.

In 1982, triplicate sediment samples were collected at twenty-six sites in the Atlantic Region had a range of L0.005 to 1.6 mg/kg and a median value of L0.005 (1). In the 1982 study, six sites coincided with those sampled in 1983 and had a value range of L0.005 to 0.009 mg/kg. Positive values in thirty-nine of forty-six sites sampled in 1979 and 1981 had an overall range of L0.005 to 1.04 mg/kg and a median value of 0.022 mg/kg (5). In the 1979 and 1981 studies, four sites from Grand Falls to Mactaquac ranged from 0.013 to 0.10 mg/kg.

TABLE 7: SUMMARY OF POLYCHLORINATED BIPHENYLS IN WATER, SEDIMENT, AND FISH (ALL SPECIES)

SITE		WATER (UG/L)	SEDIMENT (MG/KG)	#	FISH (MG/KG) RANGE	MEDIAN
1 GREEN R. RESERVOIR	SURFACE	L0.005	L0.005	17	L0.005	-
	BOTTOM	L0.005				
2 MADAWASKA RIVER	SURFACE	TRACE	L0.005	7	L0.005	-
3 SJR AT GRAND FALLS	SURFACE	L0.005	L0.005	4	TRACE	-
4 TOBIQUE RIVER	SURFACE	L0.005	L0.005	6	L0.005	-
	BOTTOM	L0.005				
5 SISSON BR. RESERVOIR	SURFACE	-	L0.005	2	L0.005-TRACE	
	BOTTOM	L0.005				
6 AROOSTOOK RIVER	SURFACE	L0.005	L0.005	6	L0.005-0.023	0.017
	BOTTOM	L0.005				
7 SJR AT BEECHWOOD	SURFACE	0.098	0.007	1	0.006	-
8 SJR AT POKIOK	SURFACE	L0.005	0.008	4	0.008-0.021	0.017
	BOTTOM	L0.005				
9 SJR AT MACTAQUAC	SURFACE	L0.005	0.017	0	-	-
	BOTTOM	L0.005				

All studies indicate a distribution at very low levels of PCBs in the Saint John River Basin. Since there is not a high center of concentration in the basin, a point source is unlikely. The use of PCBs as an evaporation retardant in some pesticides or as a pollutant in domestic sewage does not explain occurrences in remote areas such as Glasier Lake (5). Long range transport of atmospheric PCBs is probablythe principal source of input to the basin. Long range transport is also cited as the source of PCBs in precipitation (7, 8, 9) at sites in Nova Scotia.

PCBs in fish tissue samples were more widely distributed than in water and sediments. Quantitative levels of PCBs were found in ten of the forty-seven fish samples. Trace levels were found in five additional samples. PCBs in suckers in the Aroostook River ranged from ND to 0.023 mg/kg whereas samples of yellow perch at Pokiok ranged from 0.008 - 0.021 mg/kg (Table 6). A single yellow perch sample at Beechwood was slightly above the detection limit at 0.006 mg/kg. Yellow perch tissue samples from the St. Croix River, N. B. and Grand Lake, N. B. had slightly higher levels, at 0.089 and 0.13 mg/kg respectively (14). Yellow perch collected in Lake Ontario in 1975 and 1976 had mean PCB levels of 0.38 (25 samples) and 0.74 (19 samples) mg/kg respectively (11). During the same survey, mean PCB levels in lake trout ranged from 7.11 to 9.36 mg/kg whereas Coho Salmon ranged from 6.06 to 8.41 mg/kg (11). The latter samples greatly exceeded the allowable limit for human consumption of 2.0 mg/kg (14). The samples in the Saint John River were well below this limit.

3.5 Polynuclear Aromatic Hydrocarbons

Triplicate sediment samples from five of the nine sites and twenty-five fish tissue samples were analyzed for polynuclear aromatic hydrocarbons (PAHs). The PAH parameters measured are listed in Table 3. The PAH data in sediment is presented in Table 8.

Total PAH in sediments ranged from 0.055 to 0.22 mg/kg, slightly lower than values from six sample sites in the Saint John River Basin sampled in 1982 (0.16 to 0.52 mg/kg) (1). Seventeen sites in New Brunswick sampled during 1980 and 1981 surveys ranged from 0.039 to 1.40 mg/kg with a median of 0.345 mg/kg (5).

PAHs are ubiquitous in the environment and have a variety of natural and anthropogenic origins such as volcanos, forest fires and combustion of organic fuels. It is estimated that a natural background level of 0.010 to 0.020 mg/kg of PAH exists in soils and sediments (15). Although all sites exceeded the background levels, it should be noted that many pristine sites such as Lake Nictau and Magaguadavic Lake had PAH averages above the median value measured in the 1980 and 1981 surveys (5).

No PAHs were detected in twenty-five fish tissue samples from Green River Reservoir, Madawaska River, Saint John River at Grand Falls, Sisson Branch Reservoir, Aroostook River and Saint John River at Pokiok. It has been suggested that PAHs will accumulate in biota as in sediment due to their tendency to absorb on suspended particulates (16). Although they are rapidly bioaccumulated, they are also rapidly metabolized and

eliminated by the organisms, therefore bioaccumulation especially in vertebrate organisms, is considered to be short term.

3.6 Mercury

Mercury was analyzed in triplicate bottom sediment samples from six of the nine sites and in thirty-two of forty-seven fish samples collected. The data are presented in Appendices II and III and are summarized in Table 9.

Very low levels of mercury were detected in the sediment samples with the mean of the triplicate samples ranging from 0.08 to 0.19 mg/kg and a median of 0.13 mg/kg. Twenty-two sites were sampled and analyzed for mercury during a 1982 toxic survey with values ranging from 0.011 to 3.0 mg/kg and a median of 0.14 mg/kg (1). Four Saint John River Basin sites from Grand Falls to Beechwood ranging in concentration from 0.011 to 0.21 mg/kg were included in the 1982 survey. The values reported during the 1983 survey are well below the Ocean Dumping Control Act (ODCA) limit of 0.75 mg/kg, however slightly above the 0.1 mg/kg background level indicating the possibility of enrichment from anthropogenic or natural sources (17).

Mercury levels were detected in 28 of 32 fish tissue samples with a range of ND to 1.5 mg/kg, and a median of 0.24 mg/kg. One-half of these samples had mercury concentrations of less than 0.2 mg/kg, the concentration considered to be representative of natural mercury levels in fish of unpolluted environments (18).

The samples analyzed were very diverse with respect to size and species and considering the small number of samples, there would be little confidence in relationships between size, lipid content and mercury. However, some generalities concerning the higher values should be noted.

In Sisson Branch Reservoir, two land-locked salmon (ouananiche) measuring 58 cm and 38 cm exceeded the guideline of 0.5 mg/kg established by Health and Welfare Canada to protect heavy consumers of fish, with values of 1.5 and 0.84 mg/kg respectively. Higher mercury levels in fish in newly constructed reservoirs is believed to be the result of accelerated leaching of "natural" mercury from soils inundated by new reservoirs (18, 19). Levels of mercury in ouananiche caught in the Smallwood Reservoir in Labrador have very high levels of mercury ranging from 1.5 to 2.3 mg/kg whereas areas away from the reservoir had levels nearer 0.5 mg/kg. Invertebrate feeders such as suckers and whitefish rarely exceeded the 0.5 mg/kg (18).

Mercury levels in triplicate sediment samples at the Sisson Branch Reservoir averaged 0.19 mg/kg and were thus a possible source for bioaccumulation mechanisms. A Water Quality Branch survey of two basins in Labrador (20) reports somewhat lower mercury values in carnivorous fish tissue, however mercury levels in sediment were below the detection limit, indicating very small amounts of mercury will be biomagnified to the higher trophic levels of the aquatic food chain.

Sisson Branch Reservoir is heavily fished (personal communication - S. Sprague) (21) with 500-750 land-locked salmon, measuring 35 to 75 cm

TABLE 8: SUMMARY OF POLYNUCLEAR AROMATIC HYDROCARBONS AND CADMIUM IN SEDIMENTS

SITE	TOTAL PAH (MG/KG)	CADMIUM (MG/KG)
1 GREEN R. RESERVOIR	-	-
2 MADAWASKA RIVER	-	-
3 SJR AT GRAND FALLS	-	-
4 TOBIQUE RIVER	-	0.36
5 SISSON BR. RESERVOIR	0.055	0.35
6 AROOSTOOK RIVER	0.184	0.31
7 SJR AT BEECHWOOD	0.194	0.17
8 SJR AT POKIOK	0.165	0.12
9 SJR AT MACTAQUAC	0.217	0.27

TABLE 9: SUMMARY OF MERCURY IN SEDIMENT AND FISH(ALL SPECIES)

SITE	SEDIMENT (MG/KG)	FISH(MG/KG) #	RANGE	MEDIAN
1 GREEN R. RESERVOIR	-	12	LO.1-0.64	0.12
2 MADAWASKA RIVER	-	6	0.15-0.77	0.29
3 SJR AT GRAND FALLS	-	4	0.15-0.43	0.28
4 TOBIQUE RIVER	0.14	-	-	-
5 SISSON BR. RESERVOIR	0.19	2	0.84-1.50	-
6 AROOSTOOK RIVER	0.11	6	LO.1-0.19	0.11
7 SJR AT BEECHWOOD	0.08	1	0.42	-
8 SJR AT POKIOK	0.13	1	0.28	-
9 SJR AT MACTAQUAC	0.12	-	-	-

and weighing as much as 5 kg, caught annually. Although only two fish tissue samples were analyzed from this site, they had high levels for their size, the largest fish weighing approx. 1.5 kg, had mercury values three times the guideline level established to protect heavy consumers of fish in Canada.

Lake whitefish samples from Green River Reservoir and Madawaska River also had mercury values exceeding the 0.5 mg/kg level for food consumption with values of 0.64 mg/kg (20-25 cm group) and 0.77 mg/kg (18 to 23 cm group) respectively. Two similar groups of lake whitefish from Green River Reservoir had only detection limit values of L0.10 and 0.10 mg/kg of mercury. While a sample consisting of single whitefish (28 cm) had a background mercury level of 0.24 mg/kg at the same site. Considering the variability of values in similar groups of whitefish at Green River Reservoir, these values appear questionable. Mercury analysis in sediments were not completed at these sites therefore no relationships between sediment and fish can be reached.

3.7 Cadmium

Cadmium was analyzed in triplicate bottom sediment samples from six of the nine sites and in forty-six fish samples. The data in sediment are presented in Table 8.

Cadmium values in sediment ranged from 0.12 to 0.36 mg/kg, slightly above the geologic distribution of cadmium (0.15-0.2 mg/kg) (23). The values are also well below cadmium levels reported during the 1979-1981 toxic chemical surveys where sixty-two triplicate samples ranged from

L0.1 to 2.8 mg/kg and a median of 0.55 mg/kg (5).

Cadmium was not detected in the forty-six fish tissue (muscle) samples analyzed. One source suggests that cadmium accumulates mainly in the kidneys, liver and internal organs in both freshwater and marine species (24). In Labrador, low level cadmium values were detected in liver and gonads samples but not in the muscle of the same fish (20).

4.0 CONCLUSIONS

In 1983, nine impoundments in the middle and upper Saint John River Basin were screened for selected pesticides, herbicides and other toxic chemicals in water, sediment and fish.

The results indicated that organophosphate pesticides, triazine and chlorophenoxy herbicides were not present in significant levels in water, sediment or fish at the sites sampled. A single detection limit value for 2,4,5-T was recorded at Grand Falls.

Carbofuran was the only carbamate pesticide detected with the values in water slightly above the detection limit. Although the values were low, it was very late in the season (October/November) to find an insecticide which is expected to degrade rapidly. No carbamates were found in sediment or fish.

Organochlorine pesticides were found in water, sediment and fish at all sites. In water, alpha-BHC was the only OC above the detection with trace amounts of Lindane present. The detection limit values for alpha-BHC were much lower than the values observed in atmospheric precipitation collectors at Ellerslie, P.E.I. and Kejimkujik National Park. Organochlorines were detected in sediment and fish samples at all sites. DDT and its metabolites were the only OCs above the detection limit, however trace amounts of beta-endosulfan, chlordanes and alpha BHC were found in many fish samples.

The levels of OCs in sediment have remained stable in the Saint

John Basin since a WQB survey in 1976, whereas the DDT levels in fish samples are much lower than those reported during a 1972 survey. Although they were not sampled at the same sites, it may indicate a decline in the DDT available to biota.

Polychlorinated biphenyls were in one water, four sediment and ten of forty-seven fish samples with all positive values determined between Aroostook River and Saint John River at Mactaquac. The values in fish are well below the 0.5 mg/kg suggested objective for PCB residues in body tissue of aquatic organisms (10). Long range transport is the most likely pathway for the presence of PCB in the Saint John River Basin.

Polynuclear Aromatic Hydrocarbons were detected in all sediment samples, however with much lower values than determined during the 1981 and 1982 surveys. The lower values of 1983 probably reflect scouring action of the sediment by spring flushing in the river system as compared to the more undisturbed and more highly organic natural lake sites of 1981 and 1982. No PAH's were determined in twenty-five fish samples analyzed.

Mercury levels in sediments were slightly above natural background levels with a range of 0.08 to 0.19 mg/kg. Mercury was detected in 28 of 32 fish samples with a range of ND to 1.5 mg/kg and a median of 0.24 mg/kg, therefore one half the samples were below the concentration of 0.2 mg/kg considered representative of natural mercury levels in fish of unpolluted environments. In Sisson Branch Reservoir, two land-locked salmon had elevated levels of mercury with values of 1.5 and 0.84 mg/kg in 58 and 38 cm long fish. These values compare to mercury levels in

land-locked salmon (ouananiche) following the construction of the Churchill Hydro Development and subsequent flooding of Smallwood Reservoir.

Cadmium in sediment was detected in the eighteen samples analyzed from six sites, with values slightly above the geologic distribution of cadmium. No positive values for cadmium were determined in forty-seven fish samples analyzed.

5.0 RECOMMENDATIONS

(1) Sisson Branch Reservoir supports a large stocked land-locked salmon and trout population which is heavily fished for both species. Two land-locked salmon collected from this Reservoir exceeded the maximum mercury limit of 0.5 mg/kg allowable in fish intended for human consumption. They had high mercury values for the size and age of the fish (1.5 mg/kg - 58 cm and 0.84 mg/kg - 38 cm) paralleling the mercury levels in the same species from the Smallwood Reservoir, Labrador.

It is recommended an intensive survey be undertaken to determine the extent of mercury contamination in sediment, soil and the land-locked salmon and trout population in the various regions of the Reservoir. A similar study at Trousers Lake should be incorporated into the survey to determine if the same species are affected in the natural lake environment.

(2) The Toxic Chemical survey of 1983 did not place enough emphasis on the physical and chemical characteristics and use patterns of pesticides to be studied prior to the survey. As a result, the survey carried out in September and October was only adequate for long-lived pesticides and toxics such as PCB and metals.

It is recommended in future surveys that the physical and chemical characteristics and use patterns of the pesticides be incorporated in the project design, to ensure that the more short-lived pesticides such as organophosphate and carbamate pesticides, and

triazine and chlorophenoxy herbicides will be sampled during high use periods.

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APPENDIX I TOXIC PARAMETERS ANALYZED IN WATER(UG/L)

SITE		LINDANE	ALPHA BHC	PCB	2,4,5-T	CARBOFURAN	TWD (M)
1 GREEN R. RESERVOIR	SURFACE	0.0003	0.001	L0.005	L0.01	L0.025	3.5
	BOTTOM	L0.001	0.001	L0.005	L0.01	L0.025	-
2 MADAWASKA RIVER	SURFACE	0.0003	0.006	TRACE	L0.01	L0.025	3.0
3 SJR AT GRAND FALLS	SURFACE	0.0003	0.001	L0.005	L0.01	L0.025	6.0
	BOTTOM	-	-	-	0.02	L0.025	-
4 TOBIGUE RIVER	SURFACE	L0.001	0.001	L0.005	L0.01	L0.025	4.0
	BOTTOM	L0.001	0.002	L0.005	L0.01	L0.025	-
5 SISSON BR. RESERVOIR	SURFACE	-	-	L0.005	L0.01	L0.025	17
	BOTTOM	L0.001	0.004	L0.005	L0.01	L0.025	-
6 ARDOSTOOK RIVER	SURFACE	L0.001	0.001	L0.005	L0.01	L0.025	5.0
	BOTTOM	L0.001	0.001	L0.005	L0.01	L0.025	-
7 SJR AT BEECHWOOD	SURFACE	0.0004	0.002	0.098	L0.01	0.04	15
8 SJR AT POKIOK	SURFACE	L0.001	0.001	L0.005	L0.01	0.03	7.0
	BOTTOM	L0.001	0.002	L0.005	L0.01	0.06	-
9 SJR AT MACTAQUAC	SURFACE	0.0003	0.002	L0.005	L0.01	0.06	9.0
	BOTTOM	0.0003	0.002	L0.005	L0.01	0.06	-

PARAMETERS NOT DETECTED: P,P DDT; O,P DDT; P,P DDD; P,P DDE; METHOXYCHLOR; HEPTACHLOR; HEPTACHLOR EPOXIDE; ALPHA ENDOSULPHA BETA ENDOSULPHAN; ALPHA CHLORADANE; GAMMA CHLORADANE; MIREX; ALDRIN; ENDRIN; DIELDRIN; 2,4-T ATRAZINE; METRIBUZINE; SIMAZINE; ALDICARB; CARBARYL; PHORATE; GUTHION; MALATHION; DIMETHOATE IMIDAN.

APPENDIX II TOXIC PARAMETERS ANALYZED IN SEDIMENT(MG/KG)

SITE	P,P-DDT	O,P,-DDT	P,P-DDD	P,P-DDE	PCB	CADMIUM	MERCURY
1 GREEN R. RESERVOIR	L0.001	L0.001	0.002	0.004	L0.005	-	-
	L0.001	L0.001	0.002	0.006	L0.005	-	-
	L0.001	L0.001	0.002	0.006	L0.005	-	-
2 MADAWASKA RIVER	L0.001	L0.001	0.005	0.001	L0.005	-	-
	L0.001	L0.001	0.005	0.001	L0.005	-	-
	L0.001	L0.001	0.008	0.001	L0.005	-	-
3 SJR AT GRAND FALLS	L0.001	L0.001	0.004	0.003	L0.005	-	-
	L0.001	L0.001	0.003	0.002	L0.005	-	-
	L0.001	L0.001	0.006	0.002	L0.005	-	-
4 TOBIGUE RIVER	L0.001	L0.001	0.011	0.017	L0.005	0.37	0.16
	L0.001	L0.001	0.011	0.017	L0.005	0.35	0.10
	L0.001	L0.001	0.010	0.017	L0.005	0.37	0.16
5 SISSON BR. RESERVOIR	0.001	L0.001	0.010	0.012	L0.005	0.36	0.23
	0.001	L0.001	0.016	0.023	L0.005	0.28	0.15
	0.001	L0.001	0.023	0.022	L0.005	0.42	0.18
6 ARDOSTOOK RIVER	0.076	0.006	0.031	0.046	L0.005	0.33	0.09
	0.023	0.009	0.044	0.060	L0.005	0.33	0.17
	0.029	0.006	0.026	0.035	L0.005	0.27	0.08
7 SJR AT BEECHWOOD	0.016	0.003	0.010	0.011	L0.005	0.17	0.08
	0.018	0.003	0.009	0.011	0.008	0.21	0.07
	0.020	0.004	0.010	0.011	0.010	0.14	0.08
8 SJR AT POKIOK	0.024	0.003	0.008	0.010	0.016	0.10	0.12
	0.010	0.002	0.008	0.010	L0.005	0.10	0.14
	0.010	0.002	0.010	0.011	L0.005	0.15	0.12
9 SJR AT MACTAQUAC	0.020	0.004	0.015	0.017	L0.005	0.30	0.11
	0.020	0.004	0.015	0.017	L0.005	0.25	0.13
	0.023	0.005	0.013	0.017	0.043	0.27	0.12

PARAMETERS NOT DETECTED: P,P-METHOXYCHLOR; HEPTACHLOR; HEPTACHLOR EPOXIDE; ALPHA-ENDOSULFAN; BETA-ENDOSULFAN; ALPHA-(CIS)CHLORDANE; GAMMA-(TRANS)CHLORDANE; LINDANE; ALPHA-BHC; MIREX; ALDRIN; ENDRIN; 2,4-D; 2,4,5-T; ATRAZINE; METRIBUZINE; SIMAZINE; CARBOFURAN; ALDICARB; CARBARYL; PHORATE; GUTHION; MALATHION; DIMETHOATE; IMIDAN; BENZO(A)PYRENE

APPENDIX II(CONT) TOXIC PARAMETERS ANALYZED IN SEDIMENT(MG/KG)

SITE	BENZO(B) FLUORANTHENE	BENZO(B) PERYLENE	BENZO(K) FLUORANTHENE	FLUORANTHENE	INDENO(1,2,3,CD) PYRENE
1 GREEN R. RESERVOIR	-	-	-	-	-
	-	-	-	-	-
	-	-	-	-	-
2 MADAWASKA RIVER	-	-	-	-	-
	-	-	-	-	-
	-	-	-	-	-
3 SJR AT GRAND FALLS	-	-	-	-	-
	-	-	-	-	-
	-	-	-	-	-
4 TOBIQUE RIVER	-	-	-	-	-
	-	-	-	-	-
	-	-	-	-	-
5 SISSON BR. RESERVOIR	0.011	0.007	0.004	0.022	L0.006
	0.010	0.012	0.003	0.010	0.029
	0.009	L0.006	0.002	0.014	0.033
6 AROOSTOOK RIVER	0.15	0.040	0.081	0.37	0.25
	0.18	0.030	0.080	0.42	0.28
	0.11	0.039	0.052	0.27	0.26
7 SJR AT BEECHWOOD	0.035	0.017	0.016	0.086	0.086
	0.032	0.017	0.016	0.084	0.070
	0.020	0.012	0.009	0.047	0.037
8 SJR AT POKIOK	0.023	0.008	0.009	0.062	0.045
	0.035	L0.006	0.010	0.070	0.044
	0.058	L0.006	0.011	0.070	0.050
9 SJR AT MACTAQUAC	0.034	L0.006	0.015	0.064	0.095
	0.038	0.020	0.015	0.070	0.086
	0.034	0.021	0.015	0.068	0.075

PARAMETERS NOT DETECTED: P,P-METHOXYCHLOR; HEPTACHLOR; HEPTACHLOR EPOXIDE; ALPHA-ENDOSULFAN; BETA-ENDOSULFAN; ALPHA-(CIS)CHLORDANE; GAMMA-(TRANS)CHLORDANE; LINDANE; ALPHA-BHC; MIREX; ALDRIN; ENDRIN; 2,4-D; 2,4,5-T; ATRAZINE; METRIBUZINE; SIMAZINE; CARBOFURAN; ALDICARB; CARBARYL; PHORATE; GUTHION; MALATHION; DIMETHOATE; IMIDAN; BENZO(A)PYRENE

APPENDIX III TOXIC PARAMETERS ANALYZED IN FISH(MG/KG)

SITE SAMPLE IDENT.	P,P-DDT	O,P,-DDT	P,P-DDD	P,P-DDE	PCB	ALPHA CHLOR.	GAMMA CHLOR.	ALPHA BHC	MERCURY	LIPID
GREEN R. RESERVOIR										
1-A	0.001	TRACE	0.001	0.014	L0.005	TRACE	TRACE	TRACE	0.30	1.3
1-B	0.001	L0.001	TRACE	0.009	L0.005	TRACE	TRACE	TRACE	0.12	0.99
1-C	TRACE	L0.001	L0.001	0.008	L0.005	TRACE	TRACE	L0.001	0.11	0.86
1-D	L0.001	L0.001	L0.001	0.005	L0.005	TRACE	TRACE	TRACE	-	0.91
1-E	TRACE	L0.001	TRACE	0.005	L0.005	TRACE	TRACE	TRACE	-	1.2
1-F	L0.001	0.001	0.001	0.011	L0.005	L0.005	L0.005	TRACE	-	0.79
1-G	L0.001	TRACE	TRACE	0.006	L0.005	L0.005	L0.005	TRACE	L0.10	0.92
1-H	L0.001	TRACE	TRACE	0.003	L0.005	L0.005	L0.005	TRACE	0.11	1.1
1-I	L0.001	TRACE	TRACE	0.005	L0.005	L0.005	L0.005	TRACE	0.11	1.6
1-J	L0.001	TRACE	TRACE	0.007	L0.005	L0.005	L0.005	TRACE	-	1.1
1-K	L0.001	TRACE	TRACE	0.007	L0.005	L0.005	L0.005	TRACE	0.39	1.0
1-L	L0.001	L0.001	TRACE	0.007	L0.005	L0.005	L0.005	L0.001	0.41	1.6
1-M	L0.001	0.001	0.001	0.026	L0.005	TRACE	TRACE	TRACE	L0.10	2.8
1-N	L0.001	0.001	0.001	0.030	L0.005	TRACE	TRACE	TRACE	0.64	3.1
1-O	0.009	0.001	0.001	0.033	L0.005	TRACE	L0.005	TRACE	0.10	2.4
1-P	0.009	0.001	0.002	0.15	L0.005	L0.005	L0.005	TRACE	0.24	4.3
1-T	L0.001	L0.001	L0.001	0.010	L0.005	L0.005	L0.005	TRACE	-	2.2
MADAWASKA RIVER										
2-F	L0.001	TRACE	TRACE	0.006	L0.005	L0.005	TRACE	TRACE	0.77	2.0
2-H	L0.001	TRACE	0.001	0.006	L0.005	TRACE	TRACE	TRACE	-	2.2
2-I	L0.001	TRACE	TRACE	0.004	L0.005	L0.005	L0.005	TRACE	0.15	0.89
2-J	L0.001	TRACE	TRACE	0.002	L0.005	L0.005	TRACE	TRACE	0.15	1.3
2-K	L0.001	TRACE	L0.001	0.001	L0.005	L0.005	L0.005	TRACE	0.29	1.2
2-L	L0.001	TRACE	TRACE	0.001	L0.005	L0.005	L0.005	TRACE	0.24	1.8
2-M	L0.001	TRACE	TRACE	0.001	L0.005	L0.005	L0.005	TRACE	0.50	1.4
SJR AT GRAND FALLS										
4-A	0.013	0.003	0.002	0.016	TRACE	TRACE	TRACE	TRACE	0.43	1.4
4-B	0.008	0.002	0.002	0.013	TRACE	TRACE	TRACE	TRACE	0.15	1.4
4-C	0.029	0.005	0.004	0.034	TRACE	TRACE	TRACE	TRACE	0.28	2.0
4-D	0.014	0.003	0.002	0.017	TRACE	TRACE	TRACE	TRACE	0.24	1.2
TOBIQUE RIVER										
5-A	0.004	0.001	0.002	0.031	L0.005	L0.005	TRACE	TRACE	-	1.0
5-B	0.005	0.001	0.002	0.052	L0.005	L0.005	L0.005	TRACE	-	1.0
5-C	0.005	0.001	0.002	0.039	L0.005	L0.005	L0.005	TRACE	-	0.94
5-D	0.003	0.001	0.001	0.014	L0.005	L0.005	L0.005	TRACE	-	1.0
5-E	0.004	0.001	0.002	0.023	L0.005	L0.005	L0.005	L0.001	-	1.0
5-F	0.004	0.001	0.002	0.043	L0.005	L0.005	L0.005	L0.001	-	-

APPENDIX III(CONT) TOXIC PARAMETERS ANALYZED IN FISH(MG/KG)

SITE SAMPLE IDENT.	P,P-DDT	O,P-DDT	P,P-DDD	P,P-DDE	PCB	ALPHA CHLOR.	GAMMA CHLOR.	ALPHA BHC	MERCURY	LIPID
SISSON BRANCH RESERVOIR										
6-A	0.008	0.002	0.014	0.17	TRACE	TRACE	TRACE	0.001	1.5	3.0
6-B	L0.001	L0.001	L0.001	L0.001	L0.005	L0.005	L0.005	TRACE	0.84	3.1
AROOSTOOK RIVER										
7-A	0.048	0.032	0.004	0.036	L0.005	TRACE	TRACE	TRACE	0.11	1.4
7-B	0.036	0.032	0.003	0.047	0.008	TRACE	TRACE	TRACE	L0.1	1.5
7-C	0.038	0.052	0.005	0.060	0.011	TRACE	TRACE	TRACE	0.10	2.1
7-D	0.14	0.077	0.008	0.11	0.023	TRACE	TRACE	TRACE	0.19	1.9
7-E	0.12	0.060	0.005	0.084	0.017	TRACE	TRACE	TRACE	L0.1	2.8
7-F	0.15	0.019	0.009	0.12	0.022	TRACE	TRACE	TRACE	0.15	2.0
SJR AT BEECHWOOD										
8-A	0.012	0.003	0.004	0.055	0.006	TRACE	TRACE	TRACE	0.42	1.3
SJR AT POKIOK										
11-A	0.009	0.002	0.004	0.026	0.008	TRACE	TRACE	TRACE	0.28	1.2
11-B	0.012	0.002	0.008	0.038	0.017	TRACE	TRACE	TRACE	-	0.83
11-C	0.010	0.002	0.010	0.047	0.015	TRACE	TRACE	TRACE	-	0.96
11-D	0.017	0.003	0.013	0.10	0.021	TRACE	TRACE	TRACE	-	1.2

PARAMETERS NOT DETECTED: P,P-METHOXYCHLOR; HEPTACHLOR; HEPTACHLOR EPOXIDE; ALPHA-ENDOSULFAN; BETA-ENDOSULFAN; ALPHA-(CIS)CHLORDANE; GAMMA-(TRANS)CHLORDANE; LINDANE; ALPHA-BHC; MIREX; ALDRIN; ENDRIN; 2,4-D; 2,4,5-T; ATRAZINE; METRIBUZINE; SIMAZINE; CARBOFURAN; ALDICARB; CARBARYL; PHORATE; GUTHION; MALATHION; DIMETHOATE; IMIDAN; BENZO(A)PYRENE

APPENDIX IV : TOTAL FISH CATCH BY SITE AND SPECIES

SITE	LONGNOSE SUCKER	WHITE SUCKER	LAKE WHITEFISH	SPEC. TROUT	YELLOW PERCH	BROWN BULLHEAD	L.LOCKED SALMON
1 GREEN R. RESERVOIR	88	20	24	7	4	0	0
2 MADAWASKA RIVER	22	10	8	4	3	0	0
3 SJR AT GRAND FALLS	5	5	0	0	3	1	0
4 TOBIGUE RIVER	12	0	10	0	41	0	0
5 SISSON BR. RESERVOIR	0	0	0	3	0	0	6
6 AROOSTOOK RIVER	91	38	3	1	2	1	0
7 SJR AT BEECHWOOD	0	0	0	0	6	0	0
8 SJR AT PCKICK	0	0	0	0	21	0	0
9 SJR AT MACTAQUAC	0	0	0	0	0	0	0
TOTALS	218	73	45	15	80	2	6

APPENDIX V PHYSICAL DESCRIPTION OF FISH(SAMPLES)

STATION SAMPLE IDENT.	SPECIES	GROUPING	LENGTH RANGE(CM)	TOTAL WEIGHT(G)
GREEN RIVER RESERVOIR				
1-A	WHITE SUCKER	5	18-20	350
1-B	"	5	16-20	305
1-C	"	5	18	315
1-D	LONGNOSE SUCKER	5	16-20	325
1-E	"	5	16-20	310
1-F	"	5	16-20	320
1-G	LONGNOSE SUCKER	5	23	475
1-H	"	5	20-25	510
1-I	"	5	20-28	575
1-J	WHITE SUCKER	2	20-25	250
1-K	LONGNOSE SUCKER	1	35	435
1-L	WHITE SUCKER	1	35	430
1-M	LAKE WHITEFISH	5	20-23	450
1-N	"	5	20-25	500
1-O	"	5	20-25	470
1-P	LAKE WHITEFISH	1	28	220
1-T	YELLOW PERCH	4	15	165
MADAWASKA RIVER				
2-I	WHITE SUCKER	5	18-20	320
2-J				
2-K	LONGNOSE SUCKER	5	18-20	390
2-L	"	5	15-18	295
2-M	"	5	15-18	270
2-F	LAKE WHITEFISH	5	18-23	335
2-H	YELLOW PERCH	3	13-15	125
SJR AT GRAND FALLS				
4-A	LONGNOSE SUCKER	2	23-25	285
4-B	"	2	23-27	335
4-C	WHITE SUCKER	2	23-25	335
4-D	"	2	24-28	350
4-F	YELLOW PERCH	-	18-20	310

APPENDIX V PHYSICAL DESCRIPTION OF FISH(SAMPLES)

STATION SAMPLE IDENT.	SPECIES	GROUPING	LENGTH RANGE(CM)	TOTAL WEIGHT(G)
TOBIQUE RIVER				
5-A	LONGNOSE SUCKER	3	15-18	173
5-B	"	3	19-20	230
5-C	"	3	16-18	185
5-D	YELLOW PERCH	3	18-20	220
5-E	"	3	16-18	170
5-F	"	3	15	120
SISSON BRANCH				
6-A	LAND-LOCK SALMON	1	63	~1500
6-B	"	1	41	~600
ARDOSTOCK RIVER				
7-A	LONGNOSE SUCKER	5	18	278
7-B	"	5	19-20	420
7-C	"	5	19-20	435
7-D	LONGNOSE SUCKER	3	23-25	475
7-E	"	3	25-27	556
7-F	"	3	27-28	610
SJR AT BEECHWOOD				
8-A	YELLOW PERCH	6	-	-
SJR AT POKIOK				
11-A	YELLOW PERCH	5	19-20	430
11-B	"	6	16-18	344
11-C	"	4	15	150
11-D	"	4	14-16	160

APPENDIX VI MAJOR IONS, NUTRIENTS, AND METALS IN SURFACE WATER

PARAMETER	01NB01AD0006 MADAWASKA R. SEPT 22(1100)	01NB01AF0007 GREEN R. RES. SEPT 20(1400)	01NB01AF0006 SJR@GR.FALLS OCT 5(1300)	01NB01AH0010 SISSON RES. OCT 18(1500)	01NB01AH0009 TOBIQUE R. OCT 6(1000)
WATER DEPTH (M)	3.0	3.5	11.	17.	4.
PH	6.6	6.5	6.3	6.4	6.3
SPEC. CONDUCTANCE(US/CM)	126.	101.	106.	127.	98.
TURBIDITY (JTU)	1.2	0.9	0.9	0.7	0.8
COLOR	10.	L5.	25.	L5.	L5.
CALCIUM,DISS (MG/L)	19.	15.	15.	24.	16.
MAGNESIUM,DISS (MG/L)	2.5	2.4	2.4	1.5	1.7
POTASSIUM,DISS (MG/L)	0.1	L0.1	0.4	0.2	0.2
SODIUM,DISS (MG/L)	2.4	1.6	3.4	0.8	1.8
ALKALINITY (MG/L)	51.1	42.2	32.1	59.0	36.6
CHLORIDE (MG/L)	2.8	1.1	4.0	0.5	1.1
SILICA,REACTIVE (MG/L)	1.8	3.8	3.1	1.8	5.6
SULPHATE,DISS (MG/L)	6.1	4.4	11.1	4.2	7.5
SULPHATE,DISS IC (MG/L)	5.6	4.0	11.4	4.0	8.0
CARBON,DISS ORG (MG/L)	4.4	1.3	9.2	3.4	3.8
CARBON,DISS INORG (MG/L)	13.	12.	8.6	16.	10.
NITROGEN,TOTAL (MG/L)	0.13	0.24	0.18	0.14	0.18
NITROGEN NITRATE (MG/L)	0.05	0.09	0.06	0.02	0.10
PHOSPHORUS,TOTAL (MG/L)	0.007	0.008	-	-	-
MERCURY,EXT (UG/L)	L0.02	L0.02	L0.02	L0.02	L0.02
COPPER,EXT (MG/L)	0.006	0.006	L0.002	L0.002	L0.002
LEAD,EXT (MG/L)	L0.002	L0.002	L0.002	L0.002	L0.002
ZINC,EXT (MG/L)	0.03	0.03	L0.01	0.01	L0.01
CADMIUM,EXT (MG/L)	L0.001	L0.001	L0.001	L0.001	L0.001
ALUMINIUM,EXT (MG/L)	0.023	0.011	0.062	L0.010	0.046
IRON,EXT (MG/L)	0.15	0.09	0.12	0.05	0.09
MANGANESE,EXT (MG/L)	0.02	0.02	0.02	0.02	0.02
ARSENIC,TOTAL (MG/L)	0.0002	L0.0002	0.0002	L0.0002	L0.0002

APPENDIX VI MAJOR IONS, NUTRIENTS, AND METALS IN SURFACE WATER

PARAMETER	01NB01AG0002 ARDOSTOCK R. OCT 19(0900)	01NB01AJ0003 SJR@BEECHWOOD OCT 21(0930)	01NB01AK0009 SJR@POKIOK NOV 2(1400)	01NB01AK0019 SJR@MACTAQUAC NOV 2(0930)
WATER DEPTH (M)	5.	15.	7.	9.
PH	6.3	6.3	6.2	6.1
SPEC. CONDUCTANCE(US/CM)	91.	97.	104.	123.
TURBIDITY (JTU)	1.6	2.1	1.5	1.4
COLOR	50.	50.	45.	30.
CALCIUM,DISS (MG/L)	14.	15.	15.	17.
MAGNESIUM,DISS (MG/L)	2.2	1.9	2.1	2.1
POTASSIUM,DISS (MG/L)	0.2	0.3	0.4	0.5
SODIUM,DISS (MG/L)	1.9	2.3	2.7	3.9
ALKALINITY (MG/L)	30.3	31.1	33.8	40.2
CHLORIDE (MG/L)	2.3	2.7	3.3	4.5
SILICA,REACTIVE (MG/L)	4.2	4.2	4.3	3.6
SULPHATE,DISS (MG/L)	8.0	9.2	9.0	9.0
SULPHATE,DISS IC (MG/L)	7.5	8.9	9.2	9.4
CARBON,DISS ORG (MG/L)	11.	11.	9.3	5.9
CARBON,DISS INORG (MG/L)	7.5	8.0	9.1	11.
NITROGEN,TOTAL (MG/L)	0.40	0.30	0.37	0.37
NITROGEN NITRATE (MG/L)	0.22	0.17	0.21	0.26
PHOSPHORUS,TOTAL (MG/L)	-	-	-	-
MERCURY,EXT (UG/L)	L0.02	L0.02	L0.02	L0.02
COPPER,EXT (MG/L)	L0.002	L0.002	L0.002	L0.002
LEAD,EXT (MG/L)	L0.002	L0.002	L0.002	L0.002
ZINC,EXT (MG/L)	L0.01	L0.01	L0.01	L0.01
CADMIUM,EXT (MG/L)	L0.001	L0.001	L0.001	L0.001
ALUMINIUM,EXT (MG/L)	0.069	0.069	0.075	0.040
IRON,EXT (MG/L)	0.10	0.10	0.15	0.10
MANGANESE,EXT (MG/L)	0.02	0.02	0.02	0.06
ARSENIC,TOTAL (MG/L)	L0.0002	L0.00002	0.0002	0.0005